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WATER SUPPLY AND WATER QUALITY CONTROL STUDY, SKIATOOK, BIRCH, AND COPAN RESERVOIRS LOWER VERDIGRIS RIVER BASIN OKLAHOMA

Federal Water Pollution Control Administration
Dallas, Texas

May 1966

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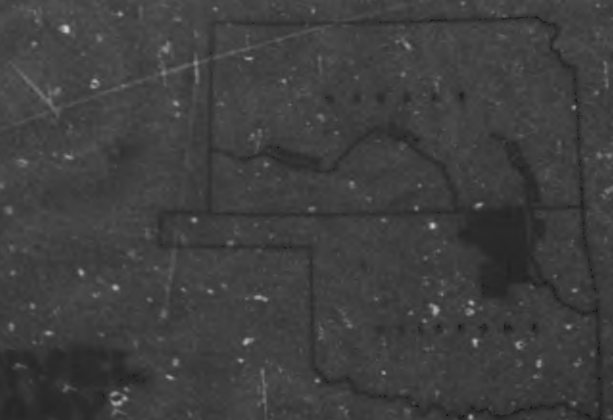
WATER SUPPLY AND WATER QUALITY CONTROL STUDY SKIATOOK, BIRCH, AND COPAN RESERVOIRS LOWER VERDIGRIS RIVER BASIN OKLAHOMA

Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control



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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
Dallas, Texas
MAY 1970

WATER SUPPLY AND

WATER QUALITY CONTROL STUDY

SKIATOOK, BIRCH, AND COPAN RESERVOIRS

LOWER VERDIGRIS RIVER BASIN

OKLAHOMA

This investigation disclosed a need for storage for water quality control purposes in the proposed Skiatook, Birch, and Copan Reservoirs. These conclusions are based on the results of economic and demographic studies.

Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Tulsa, Oklahoma

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
Dallas, Texas

MAY 1966

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I. INTRODUCTION

Request and Authority

The District Engineer, U.S. Army Engineer District, Tulsa, in letters dated October 7, 1964, and January 22, 1965, requested the Public Health Service* to investigate and report on the need for and value of storage for municipal, industrial, and water quality control purposes in the Caney River and Bird Creek basins, Oklahoma.

This study has been made in accordance with: (1) A Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958, relative to Title III of the Water Supply Act of 1958, as amended; and (2) the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466 et.seq.).

Purpose and Scope

The purpose of this study is to evaluate the water requirements for municipal, industrial, and water quality control purposes to the year 2070 in the Candy River and Bird Creek basins. Estimates are made of the value of benefits attributable to storage of water for these purposes in the proposed Skiatook, Birch, and Copan Reservoirs.

Acknowledgments

The cooperation and assistance of many persons and agencies are gratefully acknowledged. Special appreciation is expressed to the following:

Oklahoma State Department of Health
Tulsa Metropolitan Area Planning Commission
Department of Water and Sewerage, Tulsa, Oklahoma
Tulsa Health Department

*In accordance with the Water Quality Act of 1965 (Public Law 89-234), approved October 2, 1965, the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et. seq.) is now administered through the Federal Water Pollution Control Administration.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Tulsa District Office of the Corps of Engineers is conducting preconstruction planning studies on three reservoir sites in the lower Verdigris River basin, a part of the Arkansas River system in northeastern Oklahoma. The study reservoirs are Skiatook on Hominy Creek and Birch on Birch Creek, both in the Bird Creek watershed, and Copan on Caney Creek in the Caney River watershed.

2. The study area consists of Tulsa, Osage, Creek, and Washington Counties in Oklahoma, as shown on figure III-1 at the back of this report.

3. The 4 counties of the study area had a total population of about 460,000 in 1960, of which 376,000 were classified as urban (82 percent) with the remainder rural.

4. Tulsa and Bartlesville are the principal cities in the study area. They presently discharge about 13 million gallons per day (mgd) of waste flow, having a population equivalent (P.E.) of some 22,000, to the study streams.

5. Bartlesville's waste receives secondary treatment and is discharged to Caney River. The city of Tulsa discharges secondary treated waste to Bird Creek, and primary treated waste to the Arkansas River.

6. Present (1960) water use by Tulsa is almost 47 mgd with a per capita demand of 146 gallons per day (gpd) while Bartlesville uses about 4 mgd for a per capita demand of 101 gpd. Water use by major industries in the study area is nearly 12 mgd.

7. Surface water in the study basins is generally suitable for most municipal and industrial uses after conventional treatment. Periodically, oilfield brines are released to the streams in the area. Abatement of this practice is presently being undertaken, however.

Conclusions

1. The population of the study area is expected to increase from 460,000 in 1960 to approximately 1,600,000 in 2020, and 3,800,000 in 2070. The population served by

municipal water supply systems would increase from 375,000 in 1960 to about 1,530,000 in 2020, and 3,730,000 in 2070.

2. Municipal water demand for the study area is expected to increase to approximately 270 mgd in 2020, and 750 mgd in 2070. The industrial water demand was not projected beyond the year 2020 since it was not significant to this study.

3. The existing and future proposed reservoirs will more than meet the water supply needs of the study area beyond the year 2020.

4. Releases from the study reservoirs for water quality control purposes would prevent nuisance conditions from occurring in the streams and at the head of the Arkansas River navigation project and would maintain dissolved oxygen levels in the streams which will support fish life and encourage recreation and other uses of the stream.

5. There is an immediate need for storage to provide regulation to meet water quality control needs in Bird Creek. The draft-on-storage to meet these requirements is about 5,600 acre-feet per year in 1970, and is expected to increase to 75,000 acre-feet per year in 2020. Skiatook Reservoir would satisfy this need until the year 2018, and Birch Reservoir would contirute to meet this demand until nearly 2020.

6. At approximately the year 2020, the assimilative capacity of Bird Creek is exceeded. At this time the Federal Water Pollution Control Administration recommends that the amount of municipal return flow in excess of what the stream can assimilate be discharged to the Arkansas River.

7. In 1970 there is a need for 1,400 acre-feet per year draft-on-storage for streamflow regulation in Caney River which is expected to increase to 11,800 acre-feet per year by 2020, and 46,000 acre-feet per year by 2070. Releases from existing Hulah Reservoir for this purpose should satisfy this need until the year 2000. Storage in Copan Reservoir would then continue to maintain desirable quality water in the stream to the year 2030.

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3. The existing and future proposed reservoirs will more than meet the water supply needs of the study area beyond the year 2020.

4. Releases from the study reservoirs for water quality control purposes would prevent nuisance conditions from occurring in the streams and at the head of the Arkansas River navigation project and would maintain dissolved oxygen levels in the streams which will support fish life and encourage recreation and other uses of the stream.

5. There is an immediate need for storage to provide regulation to meet water quality control needs in Bird Creek. The draft-on-storage to meet these requirements is about 5,600 acre-feet per year in 1970, and is expected to increase to 75,000 acre-feet per year in 2020. Skiatook Reservoir would satisfy this need until the year 2018, and Birch Reservoir would continute to meet this demand until nearly 2020.

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8. Minimum annual values of benefits of storage for water quality control based on the cost of the most likely alternative (single-purpose impoundments at or near the project site) are as follows:

Reservoir	Date of First Need	Annual Benefit	Annual Benefits Discounted to 1970
Skiatook	1970	$760,000	$760,000
Birch	2020	105,000	23,000
Copan	2000	352,000	140,000
Total			$923,000

9. Benefits to water quality control storage in Skiatook, Birch, and Copan Reservoirs will be widespread in scope. These benefits from storage for water quality control will be realized only if adequate treatment is provided waste discharged to affected stream reaches.

III. PROJECT DESCRIPTION

The three projects under consideration are located in northeastern Oklahoma, as shown on figure III-1 following page X-2 in the Caney River and Bird Creek basins. Table III-1 presents data for these lower Verdigris River watersheds.

Copan Reservoir is situated in the Caney River basin near Bartlesville, Oklahoma, and Skiatook and Birch Reservoirs are on tributaries to Bird Creek, northwest of Tulsa, Oklahoma. Principal features of these reservoirs are shown in table III-2.

Table III-1

Watershed Data, Caney River and Bird Creek Basins

Water Course	Tributary To	Drainage Area (sq.mi.)	Length (miles)	Source	Mouth	Major Tributaries
Little Caney River	Caney River	515	60	Elk County, Kansas	Washington County, Okla. Caney River Mi. 80.5	Bee Creek
Sand Creek	Caney River	240	50	Osage County, Oklahoma	Washington County, Okla. Caney River Mi. 63.7	None
Caney River	Verdigris River	2,111	155	Elk County, Kansas	Rogers County, Oklahoma Verdigris River Mi. 78.3	Caney Creek Sand Creek
Candy Creek	Bird Creek	51	10*	Osage County, Oklahoma	Osage County, Oklahoma Bird Creek Mi. 53	None
Birch Creek	Bird Creek	67	15*	Osage County, Oklahoma	Osage County, Oklahoma Bird Creek Mi. 64	None
Hominy Creek	Bird Creek	415	60*	Osage County, Oklahoma	Tulsa County, Oklahoma Bird Creek Mi. 29	None
Bird Creek	Verdigris River	1,137	106	Osage County Oklahoma	Rogers County, Oklahoma Verdigris River Mi. 63.6	Candy Creek, Birch Creek, Hominy Creek
Verdigris River	Arkansas River	8,303	350	Greenwood County, Kansas	Muskogee County, Oklahoma Arkansas River Mi. 460	Fall River, Elk River, Big Hill Creek, Caney River, Bird Creek

*Estimate

Source: Corps of Engineers 1/

Table III-2

Pertinent Data* for Proposed Reservoirs

Features	Proposed Reservoirs		
	Skiatook	Copan	Birch
Stream	Hominy Creek	Little Caney River	Birch Creek
River Miles Above Mouth	14.3	7.4	0.8
Drainage Area (Square Miles)	354	505	66
Elevations (Feet, m.s.l.)	760.5	739.2	791.6
Maximum Pool	760.5	739.2	791.6
Flood Control Pool	729.0	732.0	774.0
Conservation Pool	714.0	710.0	750.5
Inactive Pool	657.0	637.5	730.0
Area (Acres)			
Maximum Pool	21,460	18,440	3,746
Flood Control Pool	13,950	13,680	2,339
Conservation Pool	10,540	4,850	1,137
Inactive Pool	1,480	110	384
Storage (Acre-feet)			
Maximum Pool	886,500	344,700	111,100
Flood Control Pool	513,500	229,300	58,200
Conservation Pool	331,200	43,400	19,200
Inactive Pool	11,800	600	3,360
Yield, (mgd)			
20-Year Drought	79	20	7.7
50-Year Drought	66	13.4	6

*These data are preliminary and subject to revision as may be necessary as the project studies are fully developed. These data reflect the Corps of Engineers planning as of February 1966.

Source: Corps of Engineers 2/

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area is located in the northeastern portion of the State of Oklahoma. As shown in figure III-1, the area consists of the four adjoining counties which lie to the south and east of the intersection of the Kansas - Oklahoma border and the Arkansas River. The four counties studied include the Tulsa Standard Metropolitan Statistical Area (SMSA) (consisting of Osage, Creek, and Tulsa Counties), and the Bartlesville area (Washington County).

Geography and Topography

The area under investigation consists of three general land resources areas. These are the Bluestem (Limestone - Flint Hills) region, the Cross Timbers region, and the Cherokee Prairie region. 3 4/

The Bluestem region includes most of Osage County. The terrain is rolling to hilly with steep breaks and escarpments adjacent to the stream valleys. 3/ Grades of streams rising in the region are as much as 20-feet per mile. 3/

The Cross Timbers region includes Creek County, Oklahoma and the southeastern portion of Osage County, Oklahoma. The terrain is rolling to hilly with numerous low hills and ridges. 3/ Stream valleys are moderately to deeply entrenched. 3/

The Cherokee Prairie region includes Tulsa and Washington Counties, Oklahoma. The terrain is gently rolling to nearly level with low hills. 3/ East-facing escarpments and ridges rise from the low plain. The streams have narrow channels and broad, low-lying terraces and bottoms. 3/

Climate

The average annual temperature of the study area ranges from 54° F. to 61° F.; the average annual rainfall ranges from 30 to 40 inches; April to September rainfall averages about 25 inches; and the growing season ranges from 170 to 196 days. 3 5/

Principal Communities and Industries

Tulsa and Bartlesville are the principal cities in the study area. Agriculture, mining, and manufacturing industries require most of the resources of the region. Petroleum refining is the most significant water-using manufacturing activity in the study area.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

Streamflow

Figure III-1 shows the location and general configuration of existing and proposed reservoirs in the study basins.

In the Caney River watershed, existing Hulah Reservoir has a dependable yield of 17 mgd, and authorized Sand Reservoir has a yield of 12 mgd (7.8 mgd for water supply and 4.2 mgd for water quality control). The Corps of Engineers is, in part through this report, investigating the feasibility of increasing the dependable yield of previously studied Copan Reservoir from 4 mgd (2 mgd for water supply and 2 mgd for water quality control) to 19 mgd (3 mgd for water supply and 16 mgd for water quality control).

In the Bird Creek watershed, authorized Birch and Candy Reservoirs have dependable yields of 6 mgd (3 mgd for water supply and 3 mgd for water quality control) and 4 mgd (2 mgd for water supply and 2 mgd for water quality control), respectively. Again, consideration is presently being given by the Corps of Engineers to the feasibility of increasing the yield of authorized Skiatook Reservoir from 28 mgd (14 mgd for water supply and 14 for water quality control) to 76 mgd (14 mgd for water supply and 62 mgd for water quality control).

Streamflow data for the Caney River and Bird Creek basins, together with the lower Verdigris River, and Arkansas River (at Tulsa), are summarized in table V-1. The drainage area of uncontrolled runoff for Caney River at Bartlesville is 660 square miles without Copan Reservoir, and 150 with the project. The uncontrolled drainage area of the Bird Creek watershed near Tulsa is approximately 905 square miles. With all three of the proposed projects constructed, the uncontrolled drainage area would be about 435 square miles. Unit runoff values, i.e., cubic feet per second per square mile (cfs/sq.mi.), were determined for both watersheds from period-of-record data on Caney River near Hulah, Oklahoma, and on Bird Creek near Sperry, Oklahoma. The monthly uncontrolled runoff for both basins is given in table VIII-1.

Table V-1

Streamflow Data Caney River, Bird Creek, And Lower Verdigris River Systems

Station & Location	Drainage Area (sq.mi.)	Average Flow, cfs Length of Records	Minimum Monthly Flow, cfs Date	Maximum Monthly Flow, cfs Date
Little Caney River near Copan, Oklahoma, mile 18.9	424	240 14 yrs.	0 Sev. mos.	2,499 4-44
Caney River near Hulah Reservoir mile 95.3	736	413 13 yrs.	0 Sev. mos	3,977 4-44
Bird Creek at Avant, Oklahoma, mile 54.2	364	162 12 yrs.	0 Sev. mos.	2,648 6-57
Hominy Creek near Skiatook, mile 16.8	340	159 13 yrs.	0 Sev. mos.	2,087 5-57
Bird Creek near Sperry, mile 25.0	905	474 19 yrs.	0 Sev. mos.	10,670 5-43
Verdigris River near Inola, mile 48.8	7,911	3,992 13 yrs.	17.0 9-54	41,400 6-57
Arkansas River at Tulsa, mile 523.7	74,615	6,304 32 yrs.	125 10-56	61,100 6-57

Source: Geological Survey 6/

Other authorized or existing reservoirs in the study area are Hulah, Sand, and Candy. The dependable yield on a basis of 20- and 50-year droughts is given in table V-2 with the allocation of this yield in table V-3.

Table V-2

Other Existing and Authorized Reservoirs
Caney River and Bird Creek

Reservoir	Dependable Yield (mgd) 50-Year Drought	20-Year Drought
Hulah	17	23
Sand	12	16
Candy	4	6

Table V-3

Other Existing and Authorized Reservoirs
Caney River and Bird Creek

Reservoir	Allocation of Conservation Storage (mgd) 50-Year Drought Municipal and Industrial Storage	20-Year Drought Water Quality Control Storage
Hulah	12.5	6.3
Sand	7.8	5.6
Candy	2	3

Of the three reservoirs, Hulah is existing with Sand and Candy being authorized. The allocation of the yield in Hulah has been established on the 50-year drought 12.5 mgd for municipal and industrial, and 5,040 acre-feet per year (4.5 mgd) for water quality control.

Ground Water

The principal aquifers in the study area are the alluvial deposits of the Arkansas River and a narrow belt of sandstone of the Vamossa formation covering the western half of Creek County and extending to the center of Osage County. Wells tapping alluvium deposits generally yield 100 gallons per minute (gpm) with yields of several hundred gpm common in some areas. Yields in the Vamossa formation range from a few gpm to 100 gpm. Wells in the remainder of the study area generally yield less than 50 gpm. No estimates are available on the potential yields of the above aquifers.

Quality of Water Available

Streamflow

Only a limited amount of water quality data are available for the reaches of the streams adjoining the proposed project sites. Oilfield brines are released to the streams in the area. From time to time, these releases have rendered water in various streams unsuitable for municipal and most industrial purposes by increasing the dissolved solids and chlorides concentration beyond the limits set in the Public Health Service Drinking Water Standards, 1962. 7/ However, abatement of this pollution is being undertaken by State authorities. Water to be impounded at these sites is expected to be suitable for most municipal and industrial purposes after treatment.

A resume of surface water quality data for the Caney River and Bird Creek basins, as well as the lower Verdigris River and Arkansas River (at Tulsa) is presented in table V-4.

Ground Water

Table V-5 shows the chemical quality of ground water from water supply systems of selected communities in the study area.

Table V-4

Water Quality
Caney River, Bird Creek, and
Lower Verdigris River Systems

Location	Cotton Creek Near Copan	Caney River Near Hulah Site	Birch Creek Near Skiatook	Hominy Creek Near Skiatook	Bird Creek At Barnsdall	Verdigris River Near Inola	Arkansas River At Tulsa
Temperature	77	55	57	--	56	--	--
Ca	96	63	56	25	60	42	119
Mg	16	11	12	6.8	12	9.4	33
Na&K	63	17	47	51	31	65	666
HCO_3	276	222	170	63	203	103	157
CO_3	0	0	0	0	0	0	--
SO_4	40	29	29	--	30	35	164
Cl	124	19	85	103	48	114	1,120
NO_3	0.2	1.1	1.1	--	1.7	4.2	3.0
TDS	544	277	364	--	308	368	2,300
Hardness	386	222	239	90	231	144	432
Spec. K	883	447	595	464	516	613	3,970
pH	7.8	8.1	7.5	7.6	7.6	7.8*	8.0*
Sample date	5-6-52	4-9-52	4-9-52	3-16-53	4-9-52	Oct. 52 to Sept. 53	Oct. 52 to Sept. 53
Class of Analysis	typical	typical	typical	typical	typical	weighted average	weighted average

*Approximate

All data in mg/l except Temperature - °F, Specific conductance (spec.K) - micromhos, and pH.

Source: Geological Survey 8/

Table V-5

Characteristic Analysis of Ground Water
from Water Supply Systems of Selected Communities
in the Study Area

Characteristic*	Community			
	Broken Arrow[a]	Drumright[b]	Ramona[c]	Wynona[d]
Silica (SO_2)	22	-	20	16
Iron (Fe)	0.02	-	0	0.02
Manganese (Mn)	0	-	0	0
Calcium (Ca)	11	52	67	40
Magnesium (Mg)	3.2	19	7.8	14
Sodium (Na) Potassium (K)	14	32	22	28
Bicarbonate (HCO_3)	42	224	186	205
Carbonate (CO_3)	0	10	0	0
Sulfate (SO_4)	4.9	63	25	31
Chloride (Cl)	8.5	8.2	42	11
Fluoride (F)	0	-	0	0.1
Nitrate (NO_3)	20	0.9	2.9	0.4
Dissolved Solids	119	300	295	241
Hardness	41	208	199	157
Specific Conductance (μmhos @ 25°C)	146	488	491	438
pH (pH units)	6.5	-	6.7	7.6

*Values in mg/l unless otherwise noted.

a/ Composite sample of 3 springs collected 9/5/51.
b/ Composite sample of 5 wells collected 7/25/50.
c/ Composite sample of 2 springs collected 8/31/51.
d/ Sample of 1 well collected 9/18/51.

Source: Oklahoma Planning and Resources Board 9/

VI. THE ECONOMY

The economics section serves as a basis for estimating future municipal and industrial water use and waste discharge. An economic and demographic investigation was made on the study area to the year 2020 in a recent study by the Public Health Service entitled "Storage for Municipal and Industrial Water Supply and Stream Quality Control, Sand, Copan, Birch, Candy, and Sk. .took Reservoirs, Lower Verdigris River Basin, Oklahoma," 10/ and served as a basis for the economic analysis of this report.

Present

Population

Economic activity in the study area centers around the Standard Metropolitan Statistical Area (SMSA) of Tulsa, and the city of Bartlesville. The population of the study area has increased more than four-fold in the past 50 years, from 98,803 in 1910 to 461,321 in 1960. The urban population of the study area increased from 48,772 in 1910 to 375,682 in 1960. The historical trend of the population of the study area is shown in table VI-1.

Table VI-1

Population 1910-1960
Four-County Study Area

Study Area	1910	1920	1930	1940	1950	1960
TOTAL	98,803	235,041	326,800	320,927	360,780	461,321
Urban	48,772	151,190	194,235	195,873	262,806	375,682
Tulsa SMSA*						
TOTAL	81,319	208,039	299,023	290,368	327,900	418,974
Urban	39,353	132,620	179,472	179,606	241,065	343,810
Bartlesville Area (Washington County)						
TOTAL	17,484	27,002	27,777	30,559	32,880	42,347
Urban	9,419	18,570	14,763	16,267	21,741	31,872

*Tulsa Standard Metropolitan Statistical Area, as defined by U.S. Department of Commerce, Bureau of Census, includes Tulsa, Creek, and Osage Counties.

Source: Bureau of the Census 11/

Future

The population of the study area is expected to increase to approximately 1,600,000 in 2020 and 3,800,000 in 2070. Table VI-2 shows the projected populations (total and urban) to the year 2070 for the entire study area, Tulsa SMSA, and Bartlesville area.

Table VI-2

Population Projections
Four-County Study Area

Study Area	1960*	2020 10/	2070
TOTAL	461,321	1,600,000	3,800,000
Urban	375,682	1,530,000	3,730,000
Tulsa SMSA			
TOTAL	418,974	1,440,000	3,400,000
Urban	343,810	1,378,000	3,338,000
Bartlesville Area			
TOTAL	42,347	160,000	400,000
Urban	31,872	152,000	392,000

*Source: Bureau of the Census 11/

VII. WATER REQUIREMENTS

Past and Present Water Demand

Municipal

Historic water demand data for Tulsa are presented in table VII-1 for the years 1950 through 1964. Total demand represents average quantities of water delivered to the water treatment plant including distribution system loss and treatment plant attenuation. The Tulsa municipal system supplies water to heavy water-using industry (two oil refineries). The adjusted total reflects a decrease to exclude heavy industrial water demand.

Table VII-1

Tulsa Municipal Water Demand, 1950-1964

Year	Average Total Use (mgd)	Average Adjusted Total Use (mgd)	Estimated Population Served (1,000's)	Average Demand (gpcd)
1950	26.0	23.8	220.7	108
1951	26.0	24.1	229.0	105
1952	33.0	24.1	237.2	102
1953	34.0	25.7	245.[illegible]	105
1954	38.0	26.5	253.7	104
1955	40.2	28.7	262.0	110
1956	43.5	32.0	270.2	118
1957	40.0	28.5	278.5	102
1958	42.0	30.5	286.7	106
1959	42.5	30.0	295.0	112
1960	46.9	33.5	302.0	111
1961	45.4	31.8	306.0	104
1962	47.3	32.9	311.0	106
1963	51.2	36.9	320.0	115
1964	50.8	35.9	330.0	109

Source: Tulsa Water Department personnel [12]

Similar data for the Bartlesville municipal system indicate a per capita demand of 103 in 1959 and 101 in 1960. [12]

Industrial

Industrial water demand for the study area in the year 2070 was not evaluated in this report since it does not have a direct bearing on the study. Existing and potential heavy water-using industries in the Tulsa area are now and are expected to continue to

be located in the Arkansas River basin. A more detailed explanation of this situation is given in the Water Quality Control chapter of this report.

Existing Sources of Water

The existing or firmly committed sources of water available to Tulsa for its municipal and industrial needs are the Spavinaw Lakes with a safe yield of 60 mgd, the Grand River Pump Station which will furnish 31 mgd, Oologah Reservoir yielding 141 mgd, and a reservoir on Spring Creek, a tributary to the Illinois River, yielding 30 mgd. In addition, the Illinois River is being developed and will yield another 120 mgd.

The city of Bartlesville also has a dual source for its water supply. Hudson Lake on Butler Creek has a yield of 5 mgd, and the city has a contract with the Federal Government for storage in Hulah Reservoir which has a yield of 10 mgd.

Other communities in the study area generally rely on ground water sources or small surface impoundments which are considered adequate for existing needs.

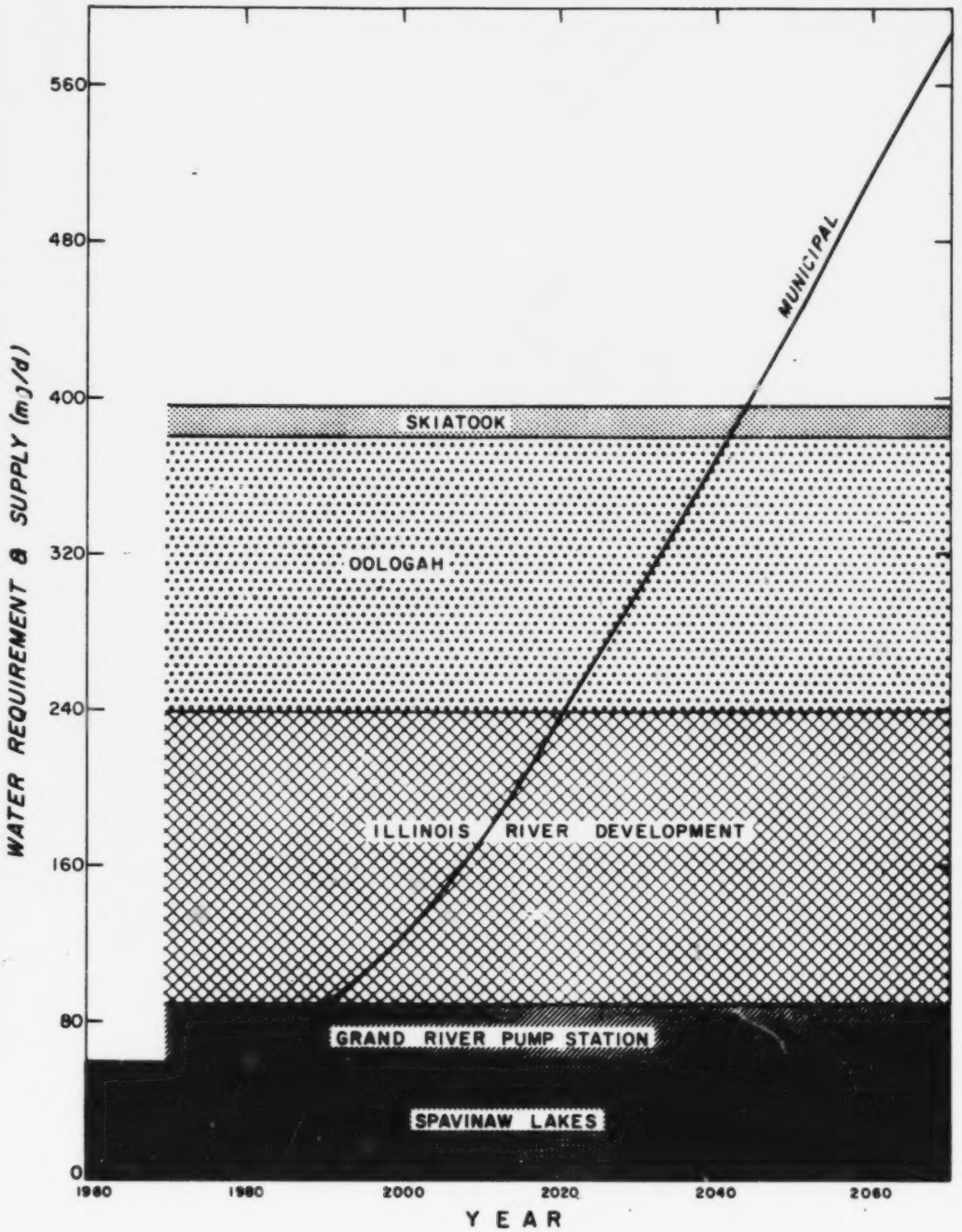
Municipal Water Demand Projections

In this four-county study area, it is expected that the urban population will closely approximate the persons to be served by a public water works system. Therefore, municipal demands were estimated by multiplying the projected urban population by a projected per capita demand figure (175 gpcd in 2020, and 200 gpcd in 2070 as developed in the Arkansas-Red River Basins, Water Quality Conservation report dated June 1964 [15]).

Municipal water demand for the study area is expected to increase to approximately 270 mgd by 2020, and 750 mgd by 2070. It is anticipated that the municipal demand in the Tulsa area will be 243 mgd by 2020, and 675 mgd by 2070 while the Bartlesville area will require about 27 mgd in 2020, and 75 mgd in 2070.

Figure VII-1 shows the water resources available for meeting the municipal water requirements of the Tulsa area while figure VII-2 indicate the water resources available to satisfy municipal and industrial water demand in the Bartlesville area.

The following requests for water supply storage in the study projects have been made by State and local interests: Skiatook Reservoir - Skiatook by resolution requested 1.5 mgd, and Sand Springs has expressed an interest; Copan Reservoir - Dewey has requested 1 mgd, and Bartlesville has indicated an interest; Birch

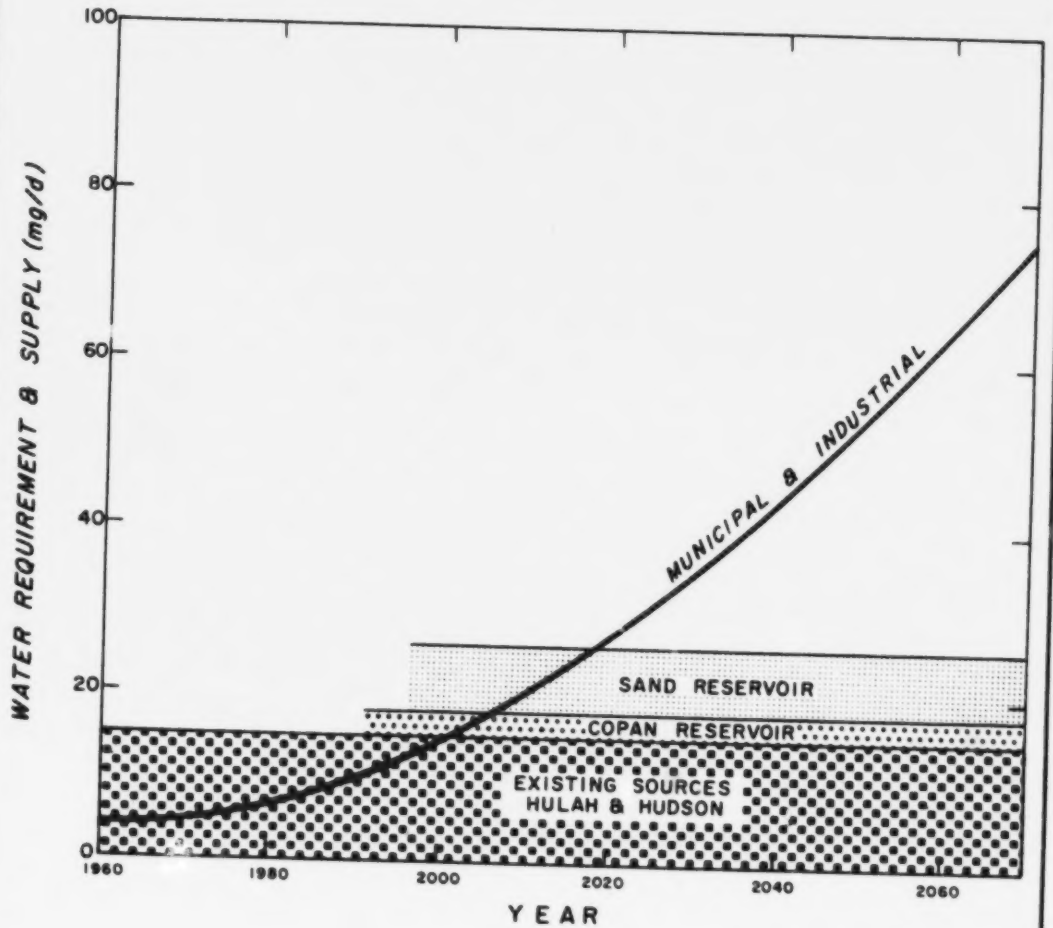


WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIRCH, COPAN & SKIATOOK RESERVOIRS
LOWER VERDIGRIS RIVER BASIN-OKLAHOMA

WATER REQUIREMENT AND SUPPLY
TULSA AREA

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Federal Water Pollution Control Administration
REGION VII Date ---- Jan 3, 1966 DALLAS, TEXAS

FIGURE VII-1



WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIRCH, COPAN & SKIATOOK RESERVOIRS
LOWER VERDIGRIS RIVER BASIN - OKLAHOMA

WATER REQUIREMENT AND SUPPLY
BARTLESVILLE AREA

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Federal Water Pollution Control Administration
REGION VII Date ----Jan 3, 1968 DALLAS, TEXAS

FIGURE VII-2

Reservoir - Oklahoma Water Resources Board has adopted a resolution requesting 3 mgd, and Barnsdall has expressed an interest.

After consideration of these specific requests for water supply and preliminary estimates of water quality control needs by the Federal Water Pollution Control Administration, the study projects are being planned by the Corps of Engineers with conservation storage to provide dependable yields as shown in table VII-2.

Table VII-2

Allocation of Conservation Storage in Skiatook, Birch, and Copan Reservoirs

Reservoir	Dependable Yield (mgd)	
	Water Quality Control	Water Supply
Skiatook	62	14
Birch	3	3
Copan	16	3

VIII. WATER QUALITY CONTROL

General

Water quality control is defined as any measure employed to enhance the utility, value, and attractiveness of waters used for purposes which are affected by changes in water quality. The use of water by man in his many activities and the subsequent return of waste effluent, even after secondary treatment, almost always causes some degradation of water quality. As population and the associated water demand increases, the problem caused by waste water becomes more significant. When the quality of the stream receiving this additional treated waste is reduced below acceptable limits, additional water is necessary to maintain acceptable conditions. This report is concerned with the possible use of releases from the study reservoirs for maintaining acceptable conditions in Bird Creek and Caney River.

Evaluation of future stream conditions and the subsequent need for water quality control in the study area is based on parameters of water quality which are currently available for use. To meet the objectives of this study, two broad parameters, dissolved oxygen content and dissolved solids, are used. Dissolved oxygen is used to measure the effect of organic waste load upon the stream. It is one of the most meaningful measures of water quality for which predictive techniques can be applied. Dissolved oxygen is a significant factor in maintaining an environment for propagation of fish and other aquatic life. The amount of dilution flow required to maintain 4 mg/l or better of dissolved oxygen throughout the influenced stream(s) was used since (1) it provides an acceptable environment for most aquatic life native to this area; and (2) it provides a buffer zone in the event unforeseen spills of waste occur.

Dissolved solids are employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by the stream environment), such as chloride and sulfate salts. Water to regulate quality is assumed to be needed when the total dissolved solids reach 500 mg/l, the upper limit recommended in the U.S. Public Health Service Drinking Water Standards.

Municipal and Industrial Pollution

Stream Loading

Waste disposal facilities discharging to the study streams may be generally described as satisfactory under present conditions. The city of Bartlesville maintains an activated sludge plant that discharges its effluent at river mile 64 on the Caney River. There are a number of waste treatment plants in the Tulsa area, both

municipally and privately owned. Discharge of Tulsa's wastes is divided between the Bird Creek watershed and the Arkansas River.

Presently, Tulsa discharges 47 percent (10.5) of its treated waste to the Arkansas River with the remaining waste (11.6 mgd) released to Bird Creek. The Comprehensive Plan for the Tulsa Metropolitan Area [13] shows that 37 percent of the subdivision development during the past ten years occurred in the Arkansas River drainage basin with expansion in the Bird Creek watershed accounting for that remaining. Based on this report, approximately 48 percent of the 1975 residential development of the city would be located in the Arkansas River drainage basin. Therefore, it is reasonable to expect that 60 percent of the future municipal waste flow of Tulsa would be released to Bird Creek with the Arkansas River receiving the remaining 40 percent.

All of the heavy water-using industries in the Tulsa area are now located in the Arkansas River basin and in some instances are now using the river water for cooling purposes. "Since construction of Keystone Reservoir, water of a more uniform mineral quality and more dependable flow is now available to meet the cooling water needs of industry in this area. As these needs increase, it is expected that the Arkansas will provide the principal source of industrial cooling water supply in the area." [14] With abatement of upstream salt pollution, [15] Keystone Reservoir and the Arkansas River could also supply industrial water demand required for processing.

The basic premise in the evaluation of water quality control requirements for Bird Creek was that the return flow loading from Tulsa would not be greater than the assimilative capacity of the stream through releases from Skiatook, Birch, and Candy Reservoirs and uncontrolled runoff. At approximately the year 2020 the assimilative capacity of Bird Creek is exceeded. At this time, the Federal Water Pollution Control Administration recommends that the amount of municipal return flow, in excess of what the stream can assimilate, be discharged to the Arkansas River in accordance with the Comprehensive Plan for the Tulsa Metropolitan Area.

The projected quantity of municipal and industrial return flow from Bartlesville was estimated to be 67 percent of the water use. Future municipal return flow from Tulsa was estimated to be 65 percent of the water use. Both return flows were estimated to have an ultimate first-stage biochemical oxygen demand (BOD) concentration of about 30 mg/l after adequate treatment. The minerals added through municipal useage were based on a loading rate of 0.23 pounds per capita per day. In estimating future waste loads, it was assumed that sufficient treatment will be provided to remove 85 percent of the BOD (used to appraise organic contaminents), and none of the total dissolved solids. With conventional treatment methods

currently used, removal of some of the total dissolved solids probably occurs, however, this removal can be considered as incidental rather than planned and no reliable estimate of the quantity so removed is available.

At the present time (1960), the average return flow from Bartlesville is 1.3 mgd with a population equivalent (P.E.) of 3,900. The return flow is expected to increase to 4.3 mgd in 1980, 18 mgd in 2020 (P.E. of 15,000), and to about 45 mgd in 2070 (P.E. of 37,500).

Tulsa is presently discharging 11.5 mgd of waste (P.E. of 18,400) into Bird Creek. Future return flow is expected to increase to 21 mgd in 1980, 103 mgd in 2020 (P.E. of 86,000), and to 250 mgd in 2070 (P.E. of 208,000).

Flow Regulation

In investigating the organic pollution of the influenced streams, the oxygen-sag equation was used to calculate the concentration of dissolved oxygen (DO) in the streams. The amount of dilution flow required to maintain 4 mg/l of DO at the critical point in the stream was determined for each month for present and future conditions. This analysis utilized low natural streamflow values based on a 95 percent recurrence interval.

Caney River

In 1970 there is a need for 1,400 acre-feet per year draft-on-storage* for streamflow regulation. This requirement is expected to increase to 2,200 acre-feet per year in 1980, 11,800 acre-feet per year in 2020, and 46,000 acre-feet per year in 2070. Table VIII-1 gives monthly tabulations of dilution flow requirements (total need) and a draft-on-storage requirements (total requirements less runoff) on Caney River for the years 1970, 2020, and 2070. Also, monthly uncontrolled runoff at Bartlesville is given, based on a 95 percent exceedence interval. Obviously, these values should not be taken as a hard and fast operating plan but used as an indication of a possible release pattern. Projected waste loads will, in all probability, vary from actual values. In addition, quantity and quality of runoff, temperature, quality of impounded water, etc. will differ in field conditions from the theoretical assumptions. Thus, operation of the reservoirs for water quality control must rely on a monitoring system on the subject stream which will reflect actual conditions.

Existing Hulah Reservoir, which has a dependable yield of 4.5 mgd for water quality control, will satisfy these requirements until about the year 2000. At this time water quality control storage from Copan Reservoir, 11 mgd, would meet dilution requirements until approximately the year 2030. Proposed Sand Reservoir, with a

*Annual draft-on-storage is the sum of the incremental excesses of needed released over inflows during a climatic year.

dependable yield of 4.2 mgd for water quality control, would maintain acceptable organic quality in the stream to the year 2040.

Bird Creek

Municipal treated waste flow from Tulsa that is discharged to Bird Creek degrades the organic condition of the stream to undesirable levels. In 1970 the draft-on-storage to meet water quality control requirements will be about 5,600 acre-feet per year, and is expected to increase to 9,000 acre-feet per year in 1980, and to 75,000 acre-feet per year in 2020. Table VIII-1 gives monthly tabulations of dilution flow requirements (total need) and draft-on-storage requirements (total requirement less runoff) on Bird Creek for the years 1965 and 2020. The monthly uncontrolled runoff near Tulsa is also given, based on a 95 percent exceedence interval. Again this release schedule for the reservoirs in the Bird Creek basin is given for planning purposes only and may be altered by actual future conditions. All indications are that water quality degradation can be limited to Bird Creek without significantly affecting the Verdigris River. However, finite definition of the existing quality problem in Bird Creek would require field work and water quality analyses beyond the scope of our current study. The Tulsa Corps of Engineers has established the sequence of construction of reservoirs in the basin as follows: Skiatook, Birch, and Candy. Releases from Skiatook Reservoir would satisfy this need until (69,440 acre-feet per year available for water quality control) approximately the year 2018. Releases from Birch Reservoir (3 mgd) and Candy Reservoir (2 mgd) would extend the acceptable streamflow conditions until 2020.

An investigation of the mineral content of the study streams shows that the total dissolved solids concentration will not exceed 500 mg/l, which is the upper limits of the Public Health Service Drinking Water Standards, by the year 2020 with releases from the study reservoirs for organic pollution.

Water Quality Control Requirements for Caney River and Bird Creek

CANEY RIVER

Month	Uncontrolled Runoff (A-F/mo.)	1970 Dilution Flow Requirements (A-F/mo.)	1970 Draft-on-Storage (A-F/mo.)	2020 Dilution Flow Requirements (A-F/mo.)	2020 Draft-on-Storage (A-F/mo.)	2070 Dilution Flow Requirements (A-F/mo.)	2070 Draft-on-Storage (A-F/mo.)
January	385	0	0	0	0	0	0
February	345	0	0	0	0	0	0
March	529	65	0	390	0	1,238	709
April	1,239	141	0	840	0	2,662	1,423
May	1,409	270	0	1,607	198	5,096	3,687
June	1,225	394	0	2,342	1,117	7,426	6,201
July	155	627	472	3,726	3,571	11,814	11,659
August	75	627	552	3,726	3,651	11,814	11,739
September	75	394	319	2,342	2,267	7,426	7,351
October	75	141	66	840	765	2,662	2,587
November	126	65	0	390	264	1,238	1,112
December	115	0	0	0	0	0	0

BIRD CREEK

Month	Uncontrolled Runoff (A-F/mo.)	1965 Dilution Flow Requirements (A-F/mo.)	1965 Draft-on-Storage (A-F/mo.)	2020 Dilution Flow Requirements (A-F/mo.)	2020 Draft-on-Storage (A-F/mo.)
January	293	0	0	0	0
February	319	0	0	0	0
March	1,920	252	0	2,166	246
April	2,351	543	0	4,659	2,308
May	6,154	1,039	0	8,918	2,764
June	2,358	1,514	0	12,995	10,637
July	662	2,408	1,746	20,675	20,013
August	236	2,408	2,172	20,675	20,441
September	679	1,514	835	12,995	12,316
October	410	543	133	4,659	4,249
November	138	252	114	2,166	2,028
December	130	0	0	0	0

IX. BENEFITS

Water Quality Control Storage Benefits

Benefits attributable to storage for streamflow regulation for water quality control may be tangible, i.e., have a measurable dollar value or intangible with no measurable dollar value. Such benefits are defined as the net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality.

Assured good quality water will provide favorable conditions for recreation such as boating and fishing for those living in and near the study area. The Fish and Wildlife Service estimates that water quality control releases from proposed Skiatook Reservoir would increase the fishing in Hominy and Bird Creek some 6,500 man-days annually; proposed Birch Reservoir would increase the annual fishing in Birch and Bird Creeks about 600 man-days. This evaluation is based on having minimum instantaneous flow in the subject stream of 5 cfs from December through May, and 10 cfs during the remainder of the year. Flow in these streams will exceed these minimum values in 2020 and 2070, with the possible exception of the month of December.

About 9,000 additional man-days of fishing annually would result from water quality control releases of proposed Copan Reservoir in the 88 miles of Caney and Little Caney Rivers. After approximately the year 2020, when minimum dissolved oxygen concentrations are exceeded in Caney River below Bartlesville, the enhanced fishing will be limited to 3,200 man-days annually in the 13 miles of Caney River upstream from Bartlesville and in the 7.6 miles of the Little Caney River from its mouth to the Copan Damsite. These estimates are based on minimum instantaneous flows in the subject streams of 5 cfs from November through March, and 10 cfs during the remainder of the year. These minimum monthly flows are exceeded in 2020, with the exception of the month of December.

In addition to recreational benefits, and falling into the intangible benefit category, riparian property owners will enjoy improved aesthetics of the stream stemming from clean surface waters and a satisfactory public health environment. Also, the Arkansas River navigation project, which is presently scheduled to be completed in 1970, will extend up the Verdigris River to the vicinity of Catoosa, Oklahoma and up Bird Creek about one and one-half miles. The Tulsa Corps of Engineers estimates that Verdigris River traffic will amount to about 8.6 million tons annually by 1980, and 28 million tons by the year 2020. 16/ Therefore, improved aesthetics at the head of navigation would provide intangible benefits from this standpoint.

If required storage for streamflow regulation is not provided as recommended, benefits described above will not be realized. Without streamflow regulation, the projected waste loads will deplete the dissolved oxygen content in the study streams during the critical months. This means that the stream will not provide the desired environment to sustain fish populations. Recreation will suffer and property values will decline in areas contiguous to the stream.

Considering all tangible and intangible benefits, storage for water quality control in the proposed reservoirs will be widespread in scope.

Senate Document No. 97 permits the following method of measuring benefits of storage in Federal reservoirs for water quality control.

> "In situations where no adequate means can be devised to evaluate directly the economic effects of water quality improvement, the cost of achieving the same results by the most likely alternative may be used as the approximation of value."

One alternative would be to transport the quantity of sewage effluent from Tulsa that exceeds the natural assimilative capacity of Bird Creek to the Arkansas River. Importing water from out of the basin, i.e., the Arkansas River, for dilution releases to Bird Creek was also investigated. After considering these plans, the most reasonable alternative is a single-purpose reservoir at the proposed project site which will provide the amount of storage used for water quality control purposes.

The first cost and the annual operation, maintenance, and replacement costs for this reservoir are based on evaluations and agreements reached by the Federal Water Pollution Control Administration and the U.S. Army Engineer District, Tulsa, Oklahoma.

Table IX-1 summarizes the alternative cost computations used for determining the value of storage for water quality control in the study projects.

Table IX-1

Summary of Alternative Cost Computations for Water Quality Control Benefits

Reservoir	First Cost $ [1]	Construction Investment $ [2]	Total Initial Investment $	Annual Cost Amortized 100-yr. @ 3 1/8% $ [3]	Annual Operation, Maintenance & Major Replacement Cost $ [1]	Total Annual Cost $ [3]	Date of First Use	Total Annual Benefit Discounted to 1970 at 3 1/8% [3]	Per 1,000 Gallons At Full Utilization	Yield [1] (mgd)
Skiatook	20,600,000	1,609,000	22,209,000	728,000	32,000	760,000	1970	760,000	3.4	62
Birch	2,640,000	82,000	2,722,000	89,000	16,100	105,000	2020	23,000	2.1	3
Copan	8,310,000	389,000	8,699,000	285,000	66,700	352,000	2000	140,000	2.4	16

[1] Data from Corps of Engineers, U.S. Army Engineer District, Tulsa.
[2] Determined by Federal Water Pollution Control Administration.
[3] Values to nearest $1,000.

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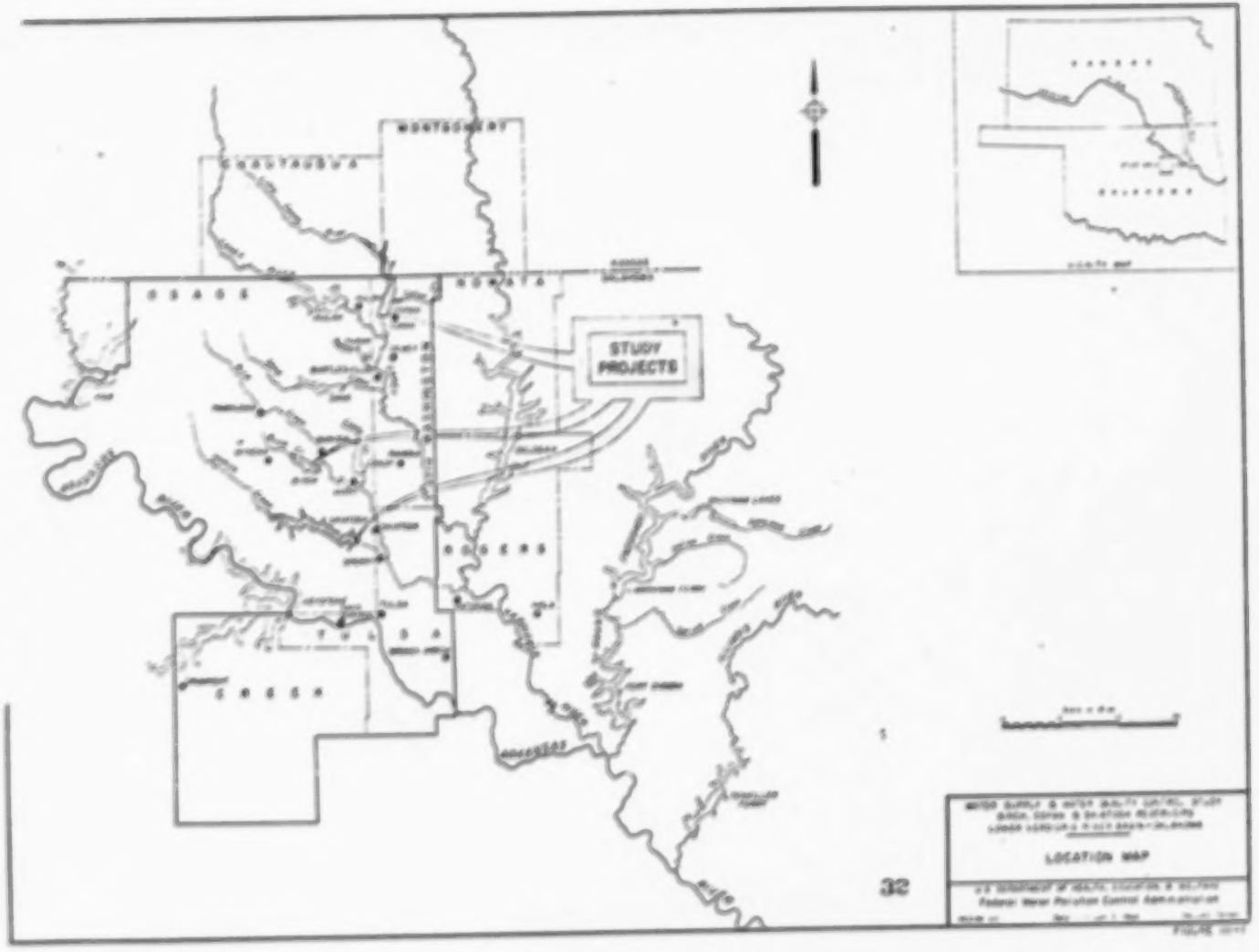

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